# CASE FOR BUILDING INFORMAL ONTOLOGY OF A SUBJECT MATTER AT SCHOOL LEVEL SCIENCE EDUCATION WITH COMMUNITY COLLABORATION

By

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***ABSTRACT***

*School science textbooks are an amalgamation of concepts collected from different fields of Science like Physics, Chemistry and Biology. The actual number of concepts in the different domains of science are enormous. Educationists have to make a decision of choosing some concept that they think are necessary for students to know at a certain age. Moreover, these concepts have to be arranged in a certain order of arrangement from first chapter to the last in a textbook. The aim of this paper is to question the ontological basis of filtering concepts from the larger world of science to placing them in a school science textbook. Through two informal studies presented in this paper, the author has tried to demonstrate that different groups of people can form concept maps of a topic that are very different in structure compared to what is given in NCERT textbook. If there are multiple ways of arranging the same set of concepts, then how do educationist validate one set of arrangement of topics against the other? The result of study puts light on the fact that currently there are no criteria available for judging the ontological validity of concepts that are present in existing textbooks in school science curriculum. The selection of topics is dependent upon limited individual knowledge base of the expert who is writing the chapter.*

*The article briefly provides a framework by which ontology of a subject can be developed collaboratively by a community of teachers and subject matter experts. This ontology can be used as a valid guide for choosing and arranging topics in a school level science textbook.*

*Keywords: Ontology, Concept map, Science Curriculum, Textbook, Collaboration*

## INTRODUCTION

Creation of ontological boundaries of subjects with the participation of students is important because in the 21st century, education of a student not just include the knowledge of already existing concepts, but creation of new ones.

A fundamental challenge for modern societies is to organise both work and learning in a way that goes beyond the reproduction and use of pre-existing knowledge and contributes to the generation of innovative solutions and knowledge, such as new theories, innovative work flows, and advanced technological products (Heidrun Allert, 2006).

Ontology is one of the core branches of philosophy. Ontology of any discipline contain within it a formal and informal structure for organising various key concepts. Any discipline of knowledge is composed of thousands of concepts draped in its varied terminology. As the discipline progresses in history, the number of concepts associated with it keep increasing with every new discovery or invention. An increasing number of concepts increases the complexity of volume of knowledge in a discipline. In this context development of Ontology becomes necessary because it reduces the number of overall concepts by limiting them to few core categories. The focus then comes on the basic important category of concepts which are few rather than knowing each and every concept floating in a particular discipline. Secondly development of a shared ontology makes visible, the underlying logic which filters the relevant from irrelevant concepts. And this logic is available to all members of a particular knowledge

community.

Ontologies are socially shared artefacts as their generation requires a cooperative process in order to gain a consensual representation of the collective knowledge on the domain. As ontologies arise as a result of cooperation within communities, they are inevitably aligned with a particular perspective on the domain of interest. This perspective defines the underlying rationale and theoretical foundation of the ontology, irrespective of it is explicitly stated or not (Heidrun Allert, 2006).

The concern for a lack of logical basis for an ontological structure in Indian school education context stems from observation of concept list in Upper Primary Science textbook. It has been noted that the concepts related to category of "Static Electricity" have been removed and replaced by Electrical appliances and electrical circuit in Upper Primary science textbooks (NCERT, Electricity and Circuits, 2006). A question naturally can be asked "What are the core concepts in the domain of electricity"? Are the core concepts subjective? Or is there an objective structure of categories that form the corpus of electricity as a knowledge domain? We do not have answers to these questions, but we are certain that these questions need answers in current Indian school education context.

Assuming that these ontologies and the logic for developing these ontologies is missing (The researchers hold this assumption as real by the fact that even NCF 2005 does not make any mention of them.) from Educational Literature, it becomes imperative to commence search for developing such ontological structures.

Secondly, by its very nature, ontologies of a domain are collaboratively built. They cannot be created by an individual expert. But the textbook chapters are written by experts individually based upon their individual knowledge. The question is how can a shared ontology of domain be developed collaboratively?

Though there is a lack of logical basis for development of Curriculum ontology in Indian context, at the international arena, such ontological structure do exist in the form of Subject matter classification schemes. Such subject matter classification schemes are published by Education Department of a state (Baker, 2012). It is surprising that such a classification of subjects is missing in India because the father of library classification is an Indian Mr. S.R. Ranganathan.

The limitation of fixed classification schemes created by an authority is that, it limits the boundary of a subject matter very rigidly. Only a few people who pursue doctoral level research in a field get an opportunity of tinkering with a domain's ontology. But if teachers and even students are involved in creating an informal ontology, then there is a possibility of expanding the limits of a domain at a faster pace than is currently possible.

In the next section, a brief account of developing basic informal ontological categories for the domain of Micro Insurance for a diploma course for Micro Insurance Academy (MIA) in Delhi, India is demonstrated.

### Scope of the Study

This study makes an attempt to develop ways and means by which school science curriculum can be made open to criticism, scrutiny and improvement by larger members of the education community namely teachers. For this to happen, the underlying ontological structure of the science textbook curriculum has to be made visible to the community as a whole. Hence the need and method for developing such ontological framework arises.

### Concept Mapping Method for Collaboratively Eliciting Core Categories in a Knowledge Domain

The concept mapping approach for mapping conceptual structure of a domain was developed by Dr Joseph Novak (Novak J. D., 2007). Concept maps are graphical representation of concepts and their relationships with each other. In this section we have tried to use this tool for developing informal Ontological categories that define the existing but not limited boundary of a knowledge domain which may differ a little from the categories developed by Experts. Though most of the relations between concepts were drawn intuitively, some relations were taken from Spradley's universal semantic relations (Whitehead, 2005). These relationship are not Strict Inclusion (X is a Y) kind which is the most basic type of classification. They are mostly "X is a part of Y" type relations(Morrisson, 2008). The conceptual relations in subject matter of Micro-Insurance are given in Figure 4 and

relations in concept of Electricity are given in Figure7.

### Procedure

A small scale exercise was conducted with 8 participants. The participants constituted 2 teachers and Six students of micro Insurance academy, Delhi. The objective of the exercise was to collectively draw out from the participants, basic core category of concepts related to the domain of Micro-Insurance.

The facilitator (the author), wrote the word Micro-Insurance on the whiteboard. Then the author started the discussion by asking questions to the participants. The first question was: "What comes to your mind, when you hear the word Micro-Insurance?" After a brief pause, some words emerged from the participants and the words were placed surrounding the word Micro-Insurance as follows:

All members agreed that these were the basic concepts related to Micro-Insurance. There was no objection to it from any member. After writing the basic concepts related to Micro-insurance on the board, the next step was to write concepts related to the core concepts as shown in Figure 1. For example "Risk" is a very general concept, but how is it related to Micro – Insurance? Then the new concepts that emerged related to Risk were Health, Crop and Livestock as shown in Figure 2.

From Figure 2, the concept "Health" is no longer a core concept. It is part of the core concept Risk. This brings clarity that "Health" is one of the "Risk" related to "Micro-Insurance" along with "Crop" and "Livestock" failure. Health, Crop and Livestock are secondary concepts because they are not

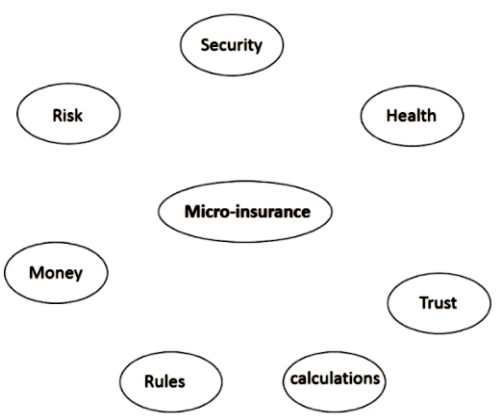


Figure 1. Core Concepts Related to Micro-Insurance

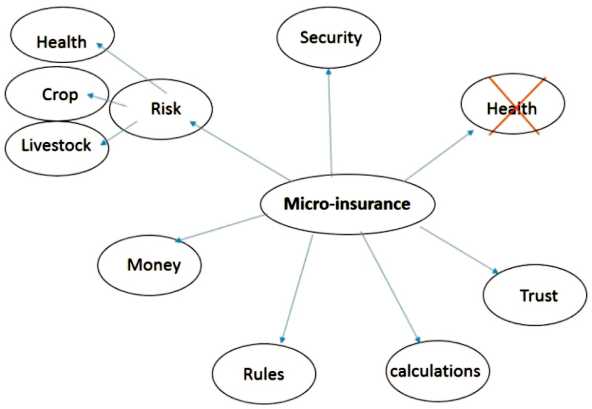


Figure 2. Secondary Concepts Related to Risk in Micro-Insurance.

directly related to Micro-Insurance, but are related to the core concept of Risk.

Similarly in the next step, the author asked the participants what comes to their mind when they think of Security in relation to Micro-Insurance. In this case, they removed Money as a core category and placed it under security and changed the name from Money to Finance after mutual discussion and agreement and added one more item "peace of Mind" which is not generally covered in standard micro-Insurance curriculum (Figure 3).

The final concept map of Micro-Insurance that emerged is given in Figure 4 (Dror, 2015).

The final concept map that emerged after discussion with the participants also form the corpus of subject matter that can form part of the Micro-Insurance curriculum. This map organises the varied range of concepts in few basic categories. It is actively being used by Micro Insurance Academy, Delhi.

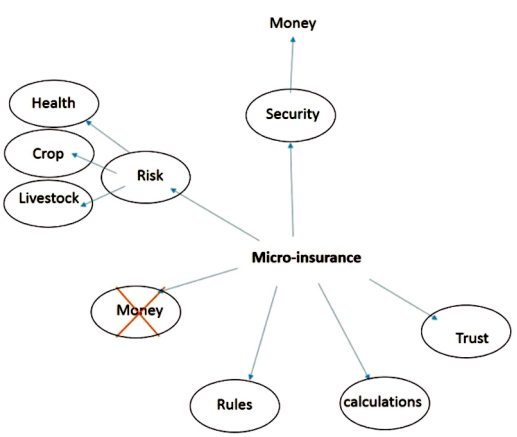


Figure 3. Positioning Money Under Security


Figure 4. Concept map of Micro-insurance.

A similar exercise was done at smaller scale with three participant at Pratham Education Foundation, Delhi, for drawing concept map of Electricity. Figures 5, 6 and 7 show iterative progression of concept map of Electricity.

Concept map of Electricity also presents the spectrum of concepts and topics that can define the boundary of the curriculum.

From the above examples, one small rule is followed. The relationship of concepts to the central concept has to go from General to Specific (from Macro to Micro). The above concept map is also subject to scrutiny by anyone. If there is an objection about positioning of some concept then it can be altered if a satisfactory argument is presented. The concept map also presents a logical sequence in which the topics can be presented one after the other from

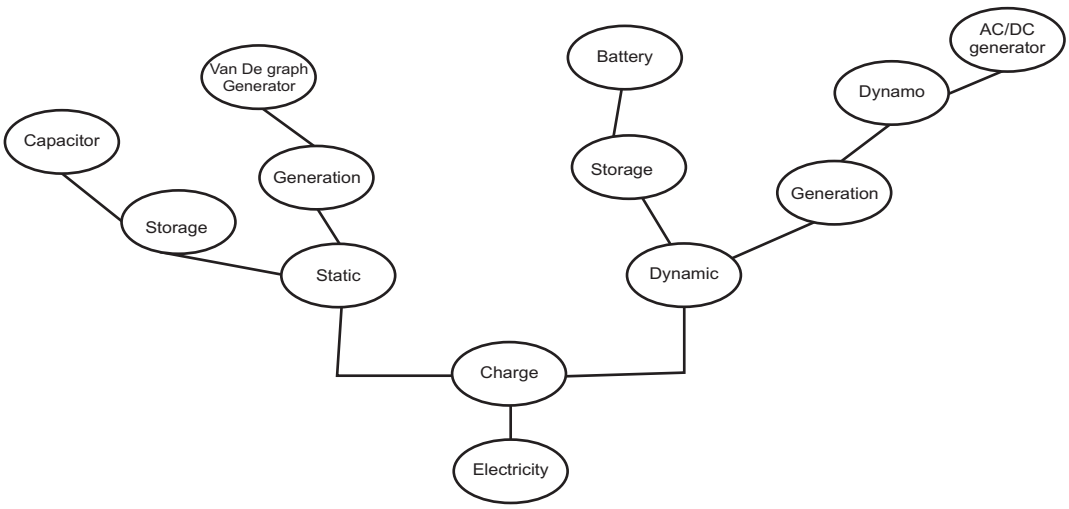


Figure 5. Stage 1: Laying Down of Concepts Related to Electricity and Clubbing them under Abstract Categories of Static and Dynamic Charge

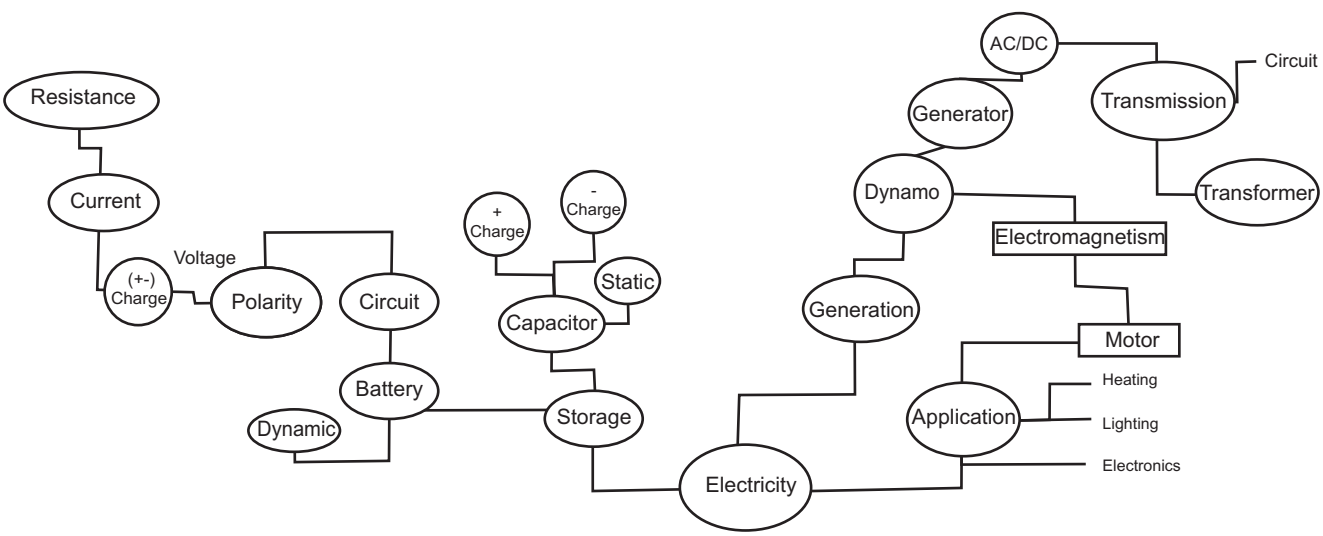


Figure 6. Stage 2: Organising Basic Electricity Concepts into Concrete Categories of Storage, Generation and Application

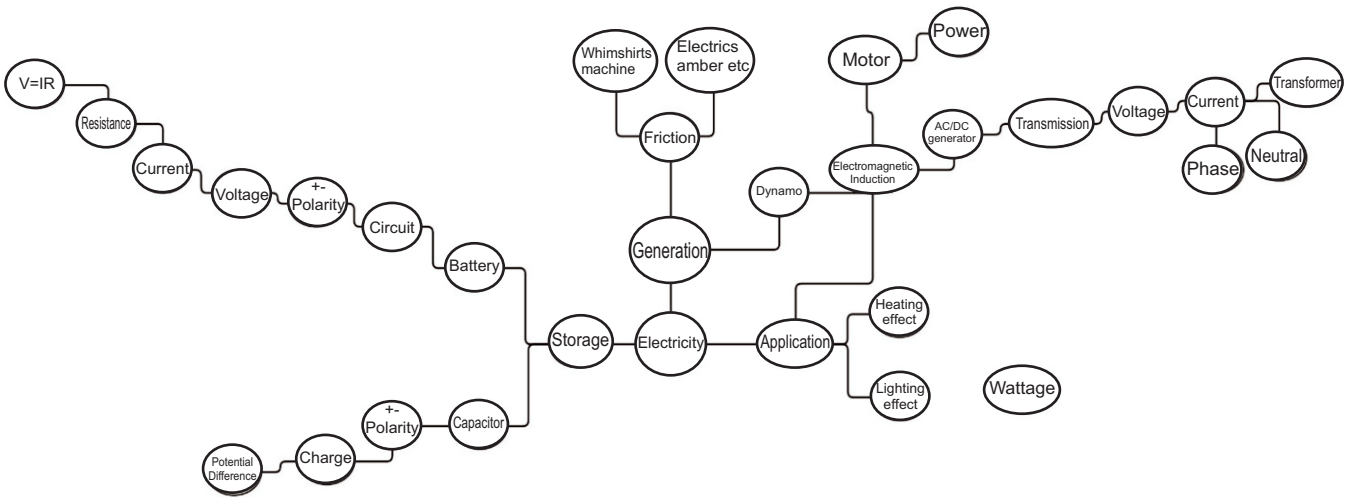


Figure 7. Stage 3 Further Simplifying the Branches from Stage 2 in Figure 6

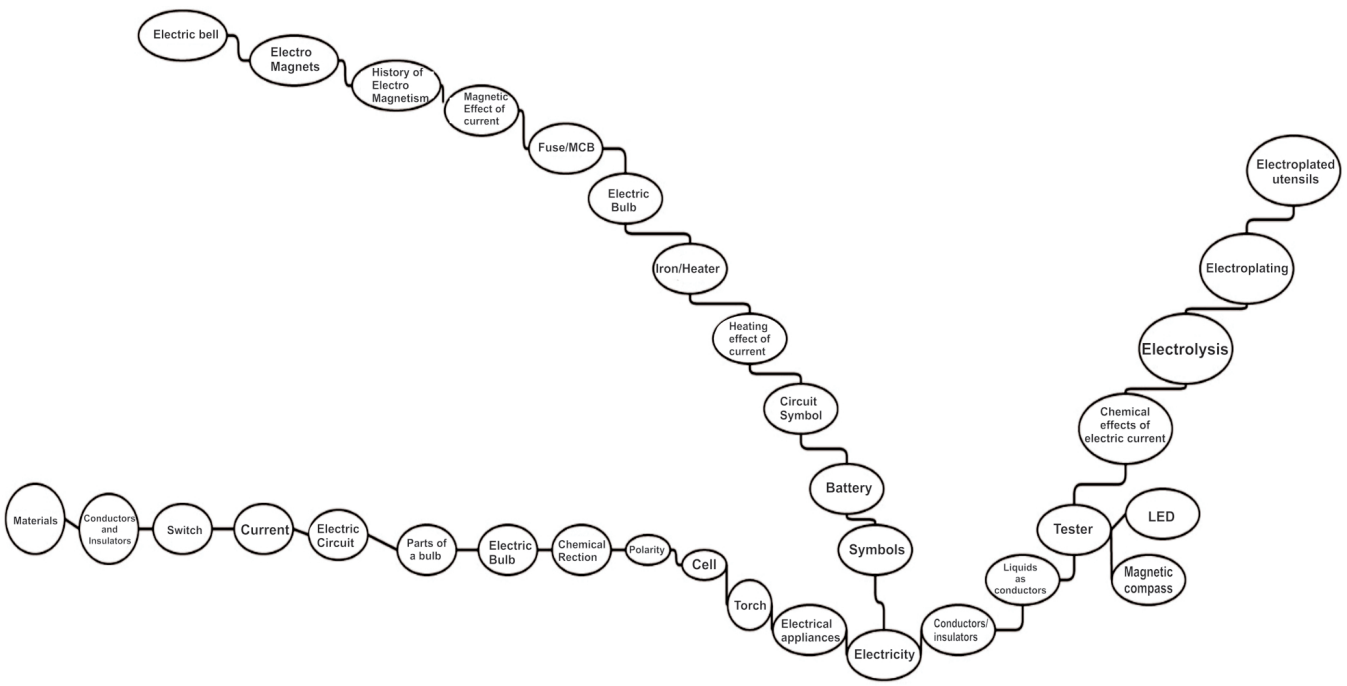


Figure 8. Concept Mapping of Topics Covered in Class 6, 7 and 8 NCERT Science Textbook, Chapter - Electricity.

general to detailed level. And most importantly anyone can challenge this structure and make changes to it. It is not something that everyone has to follow as it is. But since it has been developed collaboratively by a group of participants the relationships presented in the map are fairly accurate. Yet there may be scope for changes.

Compare the conceptual map of subject matter of electricity given in Figure 7 with concept map of Electricity chapters taken from class 6th, 7th and 8th science NCERT textbook given in Figure 8 (NCERT, Electricity and Circuits, 2006)

Notice that the concept of static electricity is completely removed from the curriculum. Is it possible to compare conceptual maps of Figure 7 and 8 and pass a judgement on which is more close to representing the fundamentals of the domain of Electricity? Or both are right in their own way and no comparison is possible. How do we weigh one concept map against the other? What is the base logic

required to do scrutiny of flow of concepts in a textbook?

### Recommendation

Apart from the informal study on use of concept maps to chart out the main concepts of a domain presented in this study, there is a wealth of research available that prove the effectiveness of concept mapping tool for eliciting main concepts in a knowledge domain (Mintzes, 1997). With this wealth of research base on Concept Mapping, it is possible to organise community workshops in which Teachers can collaboratively use the various concept mapping tools to represent the Ontological structure of a subject. The ontologies will be dynamic and get refined as more and more people give their feedback in the form of critique of existing ontology and presenting a new one. This exercise may help in making content creation process more democratic and transparent and encourage dialogue among the Authority of experts and subordinate teachers.

### Implication

In the existing school education scenario, the role of a teacher is limited to taking subject matter stored in textbooks written by experts to students. There is a distant communication gap between the teacher and the source of content because teacher does not participate in content creation of a subject matter. With the help of various Concept mapping tools developed in recent years, it is now possible for teachers to use these tools to create an ontological structure of a domain. This can be a useful tool even in the education of a Teacher to be able to critique, plan and create concepts in a particular domain of study. Teachers can make use of latest advancements in concept mapping like Refined Concept Maps (Kharatmal M., 2006) to construct scientifically precise and accurate ontological structures of a knowledge discipline and can reach the level of expertise where they can question and refine content structure created by subject matter experts.

### Conclusion

Can educators judge a concept map that defines the ontological categories of a domain as good or bad? Definitely all concept maps cannot be equally good. Can concept maps be used by a community to collectively develop ontology of a domain? If yes, then what is the logical basis for arriving at a consensus among the community members who are defining basic concepts and their relations in a subject matter? Is any literature on such a logic available in Indian context? If such a logical frame for judging the sequence of arrangement of concepts in Education is missing, then how do learners assess the academic validity of a particular science educational text? Hence the case for building a logical structure for developing informal ontology of a subject matter in a community setting holds ground.

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